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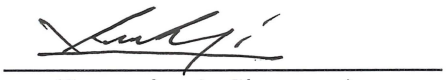
I hereby declare that I have read this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of the Master of Engineering in Civil Engineering.



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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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RAPID EXTRACTION OF FERTILIZER FROM PALM OIL MILL EFFLUENT (POME) USING MAGNESIUM AMMONIUM PHOSPHATE (MAP) PRECIPITATION METHOD AND FE-CHLORO POLYACETAMIDE (FeCP) ELECTROLYTE SYSTEM

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ABSTRAK

Sisa kilang minyak sawit (POME), sisa cecair yang diperolehi selepas pengekstrakan minyak dari buah kelapa sawit dianggap sebagai salah satu sumber utama pencemaran saluran air di Malaysia. POME terkandung sejumlah besar nutrien, bahan organik dan jumlah pepejal terampai. Pemulihan nutrien daripada POME akan memberi manfaat untuk tujuan pertanian. Pelbagai sistem yang ada wujud dalam rawatan POME bagaimanapun, sistem ini gagal menggunakan nutrien yang terkandung dalam POME kerana nutrien telah dikeluarkan sepenuhnya semasa rawatan. Penggunaan kaedah pemendakan Magnesium Ammonium Phosphate (MAP) telah ditunjukkan untuk menyediakan pendekatan yang berkesan dalam merawat air sisa yang mengandungi sejumlah besar nutrien, pada masa yang sama menghasilkan baja yang berkualiti tinggi. Kajian sebelum ini menunjukkan bahawa mendakan MAP atau struvite daripada air sisa adalah kaedah yang berdaya maju dalam pra-rawatan air sisa. Begitu juga dengan penggunaan kaedah koagulasi berasaskan biologi seperti sistem elektrolit Fe-Chloro Polyacetamide (FeCP) digunakan untuk keupayaan menstabilkan dan mengagregat koloid dalam air sisa. Hasil sampingan kedua-dua teknik ini mengandungi jumlah nutrien yang tinggi yang boleh digunakan sebagai baja. Dalam kajian ini, kedua-dua MAP dan FeCP dicadangkan dan dinilai untuk memulihkan nutrien yang penting untuk pertumbuhan tumbuhan daripada POME mentah. Kaedah pembekuan digunakan secara meluas untuk Fe-Chloro Polyacetamide (FeCP) sistem elektrolit untuk keupayaannya dalam menjumlahkan ketidakstabilan koloid. Produk daripada kedua-dua teknik boleh digunakan sebagai baja. Dalam kajian ini, untuk mendapatkan nutrien dari POME, satu kajian makmal telah dilakukan untuk menyiasat kecekapan kaedah pemendakan struvite. Mendakan struvite telah dijalankan ke atas POME mentah menggunakan $MgCl_2.6H_2O$ + $Na_2HPO_4.12H_2O$ pada pH 8, 9 dan 10. FeCP juga dianalisis untuk kitosan dengan $FeCl_3$ dan tanpa penambahan $FeCl_3$ untuk mengenalpasti keberkesanan rawatan. Rawatan ini dianalisis berdasarkan kesan dos kitosan, pH dan masa campuran. Pada akhir ujian, ciri-ciri mendakan dan peningkatan kualiti air telah dikaji. Di samping itu, kesuburan mendakan telah dinilai oleh satu set ujian percubaan menggunakan *Scindapsus Aureus.* Keputusan ujian menunjukkan bahawa, nisbah BOD/COD POME itu didapati sangat tinggi (iaitu 2.58), menunjukkan bahawa jumlah bahan organik yang tinggi mudah terurai. Selepas ujian mendakan MAP, 85.56% ammonium nitrogen telah dirawat. Mendakan diekstrak dalam kajian ini didapati mempunyai kandungan air yang berlebihan. Kajian daripada kualiti mendakan yang diperolehi. X-ray pembelauan (XRD) analisis menunjukkan bahawa, selepas pembersihan, mendakan MAP adalah sama dengan struvite tulen. Tenaga serakan X-Ray spektrometri (EDX) analisis bagi mendakan MAP mengesahkan bahawa mendakan mempunyai sama nisbah Mg/N/O/P dengan struvite yang tulen. Yang menghairankan, fluorescents X-ray (XRF) mendedahkan bahawa beberapa kesan logam berat wujud dalam semua mendakan diperolehi dengan menggunakan teknik yang berbeza. Berdasarkan ujian kesuburan, ia telah mendapati bahawa pertumbuhan *Scindapsus Aureus* menggunakan kitosan tanpa $FeCl_3$ dan mendakan MAP yang diperolehi dalam kajian ini adalah lebih baik berbanding dengan pertumbuhan *Scindapsus Aureus* menggunakan baja yang boleh didapati secara komersial. Penambahbaikan dalam kualiti air dicapai, dan didapati lebih rendah daripada had pelepasan peraturan yang dibenarkan.

ABSTRACT

Palm oil mill effluent (POME), a residual liquid waste obtained after extraction of oil from the fruits of oil palm is considered one of the main source of contamination of watercourse in Malaysia. POME contained significant amount of nutrients, organic matter and total suspended solids. Recovery of nutrients from POME would be beneficial for agricultural purposes. Various available system exist in treatment of POME however, these systems failed to utilize the nutrient contained within POME as the nutrients were completely removed during treatment. The use of Magnesium Ammonium Phosphate (MAP) precipitation method have been shown to provide effective approach in treating wastewater containing substantial amount of nutrients, at the same time produce high quality fertilizer. Previous studies have showed that MAP precipitate or struvite recovered from wastewater is a viable method for pre-treatment of wastewater. Similarly, the use of biological based coagulation method such as Fe-Chloro Polyacetamide (FeCP) electrolyte system is used for its capability of destabilizing and aggregating colloids in wastewater. The by-product of both techniques contained high amount of nutrients that may be used as fertilizers. In this study, both MAP and FeCP is proposed and evaluated to recover nutrients essential for plant growth from raw POME. A lab-scale study was performed to investigate the efficiency of struvite precipitation method in extracting struvite minerals. Struvite precipitation was carried out on raw POME using $MgCl_2.6H_2O + Na_2HPO_4.12H_2O$ at pH 8, 9 and 10. Additionally, FeCP method was tested with and without the addition of $FeCl_3$ to identify the treatment efficiency. The treatment was analyzed based on the effect of chitosan dosage, pH and mixing of time. At the end of the test, the characteristics of precipitates and improvement in the water quality parameters were evaluated. In addition, the fertility of the precipitate was evaluated by a set of pot trial tests using *Scindapsus Aureus.* Test results indicated that, the BOD/COD ratio of the POME was found to be very high (i.e. 2.58), indicating that high amount of organic are readily degradable. After MAP precipitation tests, 85.56% ammonium nitrogen was recovered. The precipitate extracted in this study was found to have excess water content. Purification process improved the quality of the precipitate obtained. X-ray diffraction (XRD) analyses indicated that, after purification, the MAP precipitate is similar to that of pure struvite. Energy Dispersive X-Ray Spectrometry (EDX) analysis of MAP precipitate confirmed that the precipitate had similar Mg/N/O/P ratio to that of pure struvite. Surprisingly, X-ray Fluorescents (XRF) revealed that some traces of heavy metals existed in all precipitates obtained using different techniques. Based on the fertility tests, it was found out that the growth of *Scindapsus Aureus* using chitosan without $FeCl_3$ and MAP precipitates obtained in this study were far superior as compared to the growth of *Scindapsus Aureus* using commercially available fertilizer. Improvements in the water quality parameters were achieved, and were found to be lower than the allowable regulatory discharge limits.

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LIST OF SYMBOLS

%	Percentage
m3	Meter cube
h	Hour
min	Minute
mg/L	Milligram per litres
°C	Degree Celcius
L	Litres
kg	Kilogram
mmol/L	Miligrammol per litres
ml	Mililitres
g	Grams
M	Mol

LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CPO	Crude Palm Oil
DO	Dissolved Oxygen
DOE	Department of Environment
EC	Electrocoagulant
EFB	Empty Fruit Bunches
EQA	Environmental Quality Act
EDX	Energy Dispersive X-Ray
FeCP	Fe-Chloro Polyacetamide
FESEM	Field Emission Electron Microscope
GNI	Gross National Income
GHG	Greenhouse Gas
HRT	High Retention Time
HR	High Range
ICPMS	Inductively Coupled Plasma Mass Spectrometry
MPOC	Malaysian Palm Oil Council
MPOB	Malaysian Palm Oil Board
MLSS	Mixed Liquor Suspended Solid

MCC	Microcrytalline Chitin
MAP	Magnesium Ammonium Phosphate
NKEA	National Key Economic Area
NF	Nanofiltration
O&G	Oil and Grease
POME	Palm Oil Mill Effluent
PORE	Palm Oil Refinery Effluent (PORE)
POMS	Palm Oil Mill Sludge
PKC	Palm Kernel Cake
PAC	Polyaluminium Chloride
RBC	Rotating Biological Contactor
RO	Reverse Osmosis
SBR	Sequencing Batch Reactor
SS	Suspended solid
TS	Total Solids
TDS	Total Dissolved Solid
TOC	Total Organic Carbon
TSS	Total Suspended Solid
TVS	Total Volatile Solids
TN	Total Nitrogen
TKN	Kjeldahl nitrogen

UF	Ultrafiltration
WWTP	Wastewater Treatment Plant
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence
Alum	Aluminium Sulphate
Ca	Calcium
CO2	Carbon Dioxide
CH4	Methane
CaCO3	Calcium Carbonate
Ca(OH)2	Calcium Hydroxide
FeCl3	Ferric Chloride
H2SO4	Sulphuric acid
HCl	Hydrochloric acid
K	Potassium
Mg	Magnesium
MgCl2	Magnesium Chloride
N	Nitrogen
NH3-N	Ammonia Nitrogen
NaOH	Sodium Hydroxide
Na2HPO4	Di-Sodium Hydrogen Phosphate

P	Phosphorus
PO_4^{3-}	Phosphate

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